

SOYABEAN MEAL SUPPLEMENTATION TO MANAGE PARASITES IN LAMBS GRAZED ON ORGANIC PASTURES IN NORTH EAST VICTORIA

Burnett, V.F.¹, Smith, M.¹, Seymour, G.R.¹ and Norng, S.²

¹ Department of Primary Industries Victoria, Rutherglen Centre, RMB 1145 Chiltern Valley Road, Rutherglen, Victoria 3685, Australia

² Department of Primary Industries Victoria, Knoxfield Centre, 621 Burwood Highway, Knoxfield, Victoria 3180, Australia

* Telephone: +61 2 6030-4575, Email: viv.burnett@dpi.vic.gov.au (corresponding author)

Abstract

Over 20,000 organic lambs are produced from southern Australian farming systems each year. Internal parasite infection of organic sheep and lambs is the most common production issue mentioned by producers. In organic systems, anthelmintic drenches are prohibited under current Australian organic standards, so producers rely on cultural methods such as lower stocking rates and rotational grazing. Recent research investigated the use of supplementary protein in the management of parasites in lambs. Experiments were conducted in 2005 and 2006 to investigate the use of soyabean meal as a source of supplementary protein to reduce faecal egg count (FEC) in lamb finishing systems on either annual or perennial organic pastures. Lambs were supplementary fed with organic soyabean meal equivalent to 2.4 MJ/kg DM ME per head per day and 51g/head/day CP in 2005, and in 2006, 2.1 MJ/kg DM ME per head per day and 61 g/head/day CP; this was compared to non-supplemented lambs grazing pasture only. Soyabean meal supplementation did not reduce FEC, with the exception of only one from a total of 14 samplings in the two pasture systems over two years. This was likely due to high CP in the pasture, rotational grazing practice and limitations with the FEC methodology. Soyabean meal supplementation improved lamb growth rates in both finishing seasons on annual pasture, but final liveweight was only increased in 2006. Soyabean meal supplementation did not improve growth rate or final liveweight on perennial pasture in either season. Soyabean meal supplementation resulted in heavier ($P<0.05$) Hot Standard Carcase Weight in lambs grazing annual pasture in 2005. Soyabean meal supplementation of lambs grazing pasture is unlikely to be effective in seasons and under pasture conditions similar to those tested in this study.

Key words: soyabean meal supplementation, lambs, parasites, organic

Introduction

Over 110,000 lambs are produced from Australian organic farming systems each year, with at least 20,000 lambs being produced from Victoria, South Australia and Tasmania (Hannigan 2007). One of the most common issues affecting organic lamb production in southern Australia is gastrointestinal nematode parasite infection. In a telephone survey of 75 organic sheep producers in Victoria, South Australia and southern New South Wales, where producers were asked to list the issues that were affecting their production system, parasite infection was the most cited production issue (Smith, *pers. comm.* 2004). This result concurs with other published data that regard parasite infections as being the most significant factor contributing to health problems in sheep and lambs (Cabaret *et al.* 2002, Besier and Love 2003). The annual cost of internal parasite infection in sheep is estimated at \$369 million nationally, or \$5.11 per head in the winter rainfall dominant production areas (Sackett *et al.* 2006).

In the high rainfall zones of southern Australia, the main species of parasitic worm affecting sheep and lambs are Black Scour Worm (*Trichostrongylus* spp.) and Brown Stomach Worm (*Teladorsagia circumcincta*) (Besier and Love 2003). Parasitic infection in sheep and lambs can negatively impact weight gain and skeletal growth, along with decreased milk and wool production (Coop and Holmes 1996). In the high rainfall zone, lambs are typically finished on annual pasture after autumn lambing, or on lucerne-based pasture systems after spring lambing.

In organic sheep production systems, anthelmintic drenches are prohibited under current Australian organic standards (NASAA 2004, BFA 2006). The focus in organic livestock systems is to minimise health problems through the adoption of specific health management strategies (Vaarst *et al.* 2004). There is a range of cultural management strategies that can be used to reduce the effect of parasites in sheep (Barger 1997), including varying stocking rates, timing of reproductive events, clean pastures, rotational grazing, alternate grazing by hosts, use of forage crops or hay/silage, varying the proportion of adult and young livestock,

choice of pasture species (Morley and Donald 1980), and breeding for resistance to parasite infection (Eady *et al.* 1996). In southern Australian organic sheep systems, producers concentrate on rotational grazing strategies and ensuring clean pastures, lower overall stocking rates, monitoring the level of worm infection, and selecting livestock for resilience to worm infection (Wynen 1992). Even with these cultural practices, parasite infection is still a major issue for sheep producers in southern Australia, and additional non-chemical control measures are required.

Protein is an essential component of the diet of ruminants; and the requirement for growth in weaned lambs is estimated to be 11-13% crude protein at 10.5-11.0 MJ/kg DM metabolisable energy (Freer 2007). Organic lamb is produced from pasture-based systems but, due to the seasonal changes in the growth and quality of pasture species, these systems often do not supply sufficient dietary protein for weaned lambs to achieve production targets. If there is insufficient dietary protein, growth rates of lambs (Liu *et al.* 2003) and resistance to parasite infection (Datta *et al.* 1998) can be negatively affected. This is because the immune response to parasitic infection competes for nutrient resources with other functions in the body (Coop and Kyriazakis 1999), so lambs that are growing rapidly may have increased susceptibility to infection (Datta *et al.* 1998).

Recent research has investigated the use of supplementary protein in the management of parasites in lambs (Datta *et al.* 1998, Kahn 2003, Steel 2003, Keatinge *et al.* 2004). It is suggested that a diet that increases the supply of metabolisable protein may allow Merino lambs to exhibit improved resistance against worm burdens without compromising growth rates and production (Steel 2003). Additional organic protein can be supplied via a supplementary feed source such as organic soyabean meal. It has been shown that soyabean meal supplementation can reduce faecal egg counts of *Haemonchus contortus* in Hampshire down lambs at specific times during the finishing phase after artificial infection (Wallace *et al.* 1995). In a similar experiment using Scottish blackface lambs, which are considered to be genetically resistant to helminths (Wallace *et al.* 1996), soyabean meal supplementation did not result in statistically different faecal egg counts from non-supplemented lambs. In the Scottish Blackface study, lambs receiving supplementation had higher weight gains and their carcasses were leaner than lambs without supplementation (Wallace *et al.* 1996).

The aim of our study was to investigate the effect of organic soyabean meal supplementation, as a protein source, on the growth and worm resistance of weaned crossbred lambs within two organic, pasture-based finishing systems. It was hypothesised that lambs receiving protein supplementation would have increased growth rates and reduced faecal egg counts (FEC).

Materials and Methods

Site details

Our experimental site was located at the Department of Primary Industries (DPI) Rutherglen Centre (36°06'45.67"S; 146°31'20.17" E; elevation 177 m), north east Victoria between January 2005 and February 2007. The soil type was classified as Chromosol, sub order brown (Isbell 1996).

Experimental design and treatments

Two experiments were conducted during 2005-07 to determine the effectiveness of organic soyabean meal as a protein supplement for increasing lamb growth rate and reducing faecal egg counts in lambs grazed on annual (Experiment 1) or perennial (Experiment 2) pastures. The factor tested was soyabean meal as a protein supplement (supplement). Experiment 1 commenced at lamb weaning in August 2005 and concluded in October 2005, and was repeated in 2006 from August to November. Experiment 2 commenced at lamb weaning in October 2005 and concluded in December 2005, and was repeated in 2006 from October to January. Prior to the experiments commencing, ewes and lambs grazed on mixed pasture in an adjoining paddock to the experimental site.

Experiments 1 and 2 consisted of eight plots, each with six (3 ewes and 3 wethers) second cross 4-months old lambs (first cross ewe [Merino*Border Leicester] ram [*White Suffolk]) allocated to each plot. Lamb liveweight (straight off feed) at lamb weaning was used to stratify the lambs for allocation to the plots. Four of the eight plots in each experiment were allocated for supplementary feeding and four plots allocated for nil supplementation. The allocation was performed using the CDESIGN procedure in GenStat 11 (Payne *et al.* 2008a).

Each plot was 0.64 ha and was subdivided into three sub plots of 0.21 ha to allow for rotational grazing. Lambs were rotated through the sub-plots when feed on offer was reduced to 1100 kg DM/ha or when a

maximum period of three weeks had lapsed. The stocking rate was determined following the recommendations of Saul and Kearney (2002).

Supplementary feeding

The supplement provided to the lambs was a certified organic soyabean meal (KR Castlemaine™ 64 Richards Road, Castlemaine, Victoria). Supplemented lambs were fed 1.98 kg fresh weight soyabean meal/plot (6 lambs) three times per week to provide an average allocation of 141 g/head/day. All supplement feed was consumed by the lambs. Nil supplemented lambs grazed pasture only with no additional supplementation.

Based on the nutritional value of the soyabean meal (Table 5a), in 2005 the rate of supplementation was equivalent to 2.4 MJ/kg DM ME per head per day and 51g/head/day CP, and in 2006 was equivalent to 2.1 MJ/kg DM ME per head per day and 61 g/head/day CP. This rate of supplementation was aimed at providing supplemented lambs on both pasture systems an average of 20% more CP than non-supplemented lambs. It is recognised that the variable nature of pasture growth, which is dependent on rainfall, nutrient availability and grazing pressure, will influence the effectiveness of the supplementation. The rate of supplementation was calculated at the start of the experiment using the liveweight of the lambs (22 kg), the daily requirement for pasture DM (1.4 kg), the CP of the pasture system (19.2% annual and 16.7% perennial) and the soyabean meal (38%). Previous studies (Wallace *et al.*, 1996) have increased crude protein via soyabean meal in excess of 40% over the basal diet, but the nutritional analyses on the pasture systems for this experiment indicated crude protein at sufficient levels (193 g/kg DM), so an increase of only 20% using soyabean meal was used. Lambs on annual pasture receiving supplement were fed via troughs (1.45m × 0.4m) in plot groups from 8 August until 24 October in 2005, and from 14 August until 14 November in 2006. Lambs on perennial pasture receiving supplement were fed via troughs (1.45m × 0.4m) in plot groups from 31 October until 17 December in 2005, and from 30 October 2006 until 29 January 2007. In the 2006-07 finishing season on perennial pasture, poor pasture growth due to drought conditions required that animals receive supplementary feeding with oaten hay from 18 until 30 January 2007. Lambs in perennial pasture blocks received 6.3 kg oaten hay/head/week; this supplied 64% of their estimated daily intake of 1.4 kg DM/day.

Animal measurements

Faecal egg count (FEC) was measured from samples taken directly from the rectum and analysed according to the method of Whitlock (1948). FEC sampled from experimental lambs were not tested for individual worm species because of funding constraints. Prior to the experiment commencing, however, FEC was measured on the ewes as a mob to determine the worm species that were present; these were *Nematodirus* spp. (Thin Necked Intestinal Worm), *Oesophagostomum* spp. (Large Bowel Worm), *Ostertagia* spp. (Brown Stomach Worm) and *Trichostrongylus* spp. (Black Scour Worm). Lambs were weighed (full, not fasted) at weaning, and on each rotational cycle during the finishing periods. A timetable of FEC and liveweight assessment is shown in Table 1.

Table 1. Start and finish dates, and FEC sampling and liveweight assessment, shown by days during the experiment.

	2005 Expt. 1	2005 Expt. 2	2006 Expt. 1	2006 Expt. 2
Start	6 July - Day 1	17 Oct - Day 1	4 July - Day 1	20 Oct - Day 1
FEC sampling, liveweight assessment	Day 56, Day 63, Day 90, Day 98	Day 23, Day 50, Day 62	Day 42, Day 99, Day 134	Day 41, Day 82, Day 102
Finish	11 Oct - Day 98	17 Dec - Day 62	14 Nov - Day 134	29 Jan - Day 102

Lamb growth rate from weaning to final liveweight (g/day) was calculated by subtracting weaning live weight from final live weight, and dividing this number by the number of days between weaning and final liveweight. All lambs in the experiment were slaughtered when the average liveweight in each finishing group reached 45 kg (full). This weight was used as being indicative of required market liveweight to achieve maximum return to producers. Hot Standard Carcase Weight (HSCW) was also analysed for treatment differences.

Pasture composition and management

The annual pasture plots, established in June 2004, consisted of subterranean clover (*Trifolium subterranean* L. cvs. Goulburn and Riverina) and annual ryegrass (*Lolium rigidum* Gaud. cv. Wimmera). The

perennial pasture plots, also established in June 2004, consisted of lucerne (*Medicago sativa* L. cv. Genesis), phalaris (*Phalaris aquatica* L. cv. Siroso), plantain (*Plantago lanceolata* L. cv. Tonic) and chicory (*Chicorium intybus* L. cv. Grouse). All pasture blocks were top-dressed with 20 kg P/ha (172 kg/ha as Guano™); they had not been grazed prior to the start of the experiment.

Pasture measurements

Total dry matter (DM) of pasture (t/ha) was assessed using a falling plate disk (Bransby *et al.* 1977), before and after each grazing rotational cycle on one sub plot in each plot. Dry matter contribution of dominant pasture species was assessed using the dry-weight-rank method according to 'T Mannetje and Haydock (1963). Dry matter was assessed seven times during the 2005 finishing period on 27 June, 4 July, 29 August, 10 October, 17 October and 12 December, and on 8 February in 2006. Dry matter was assessed five times during the 2006 finishing period on 3 July, 8 August, 10 October and 28 November, and on 13 February in 2007.

Pasture samples for nutritive characteristics were collected from each plot (15/plot) using a ring quadrat (30 cm diameter); this was thrown randomly, the pasture was cut using shears to obtain a sample close to ground level, and then bulked for annual or perennial pasture Feedtest assessment. Pasture samples for both annual and perennial were taken in 2005 on 27 June, 29 August, 11 October and 12 December, in 2006 on 10 July, 15 August, 6 October and 28 November, and in 2007 on 8 January.

Herbage samples were analysed (Feedtest, Hamilton, Department of Primary Industries, Victoria) for CP (nitrogen concentration $\times 6.25$), neutral detergent fibre (NDF) and dry matter digestibility (DMD). Values were estimated for all samples using near infrared spectroscopy (NIR). Metabolisable energy (ME) (MJ/kg DM) values were calculated from predicted DMD values using the formula: $ME = \{0.164 (DMD\% + EE) - 1.61\}$ where EE = Ether Extract (% of DM), but assumed to be 2% for all types of fodder (AFIA 2002).

Daily pasture intake of the lambs was not measured because of project constraints. However, the total DM of pasture was measured for each plot during the finishing periods to obtain average feed on offer.

Statistical analysis

To assess the significance of difference between supplementation and no supplementation, the plot-level data for each characteristic (final liveweight, growth rate (weaning to final), HSCW and total FEC) were analysed using analysis of variance (ANOVA) appropriate for a split-plot design (where sex was used as the split/blocking variable). The analyses involving weight and growth rate were adjusted for the lamb's initial birth weight (used as covariate) to account for any variability in birth weight that may impact on liveweight and growth rate. FEC data were summed at each sampling time, as repeated measures of ANOVA yielded the same results as summed data. Post-ANOVA residuals-based diagnostic plots also showed that, for each characteristic, the data reasonably met the ANOVA assumptions. Total FEC was log-transformed prior to analysis to normalise variances. All statistical analyses were performed in GenStat 11 (Payne *et al.* 2008b).

Results

Effect of soyabean meal supplementation on faecal egg count

Soyabean meal supplementation did not reduce FEC in either experiment over the two years. Worm numbers in Experiment 1 reflected the increasing trend in epg associated with the onset of milder and moister spring conditions (Figures 1 and 3). In both experiments, worm numbers were higher in the 2006 finishing season than in the 2005 finishing season. In 2006 in Experiment 1, worm numbers were elevated (not significant) during August through to October (average of 486 epg), although no clinical signs of parasite infection were observed in the lambs. Soyabean meal supplementation reduced ($P < 0.05$) FEC in only one sampling from a total of 14 samplings from the two experiments over the two years (107 vs. 150 epg lsd 38; 9/1/07 Experiment 2) (Figure 2). Worm numbers were below 300 eggs per gram of faeces (epg) in Experiment 2 in both years; this reflected the decreasing trend in FEC with the onset of warmer, drier conditions (Figures 2 and 3).

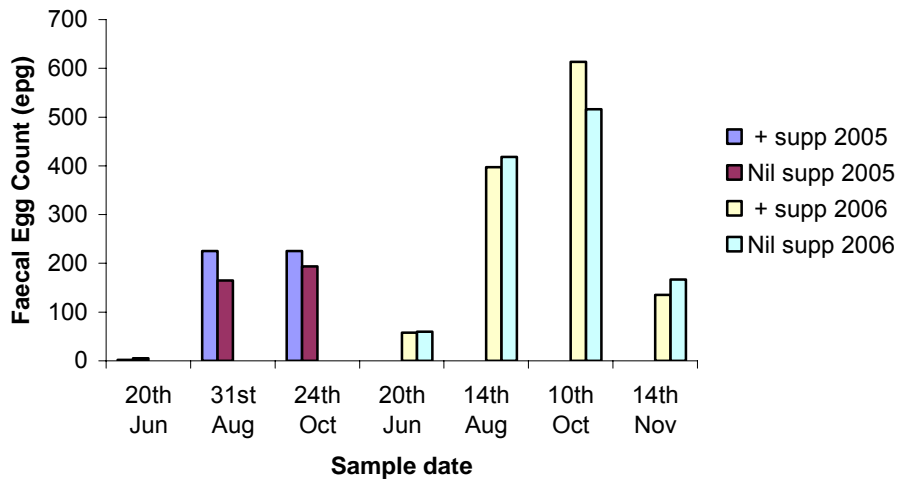


Figure 1. FEC (epg) in Experiment 1 in 2005 and 2006; no significant differences with soyabean meal supplementation on annual pasture.

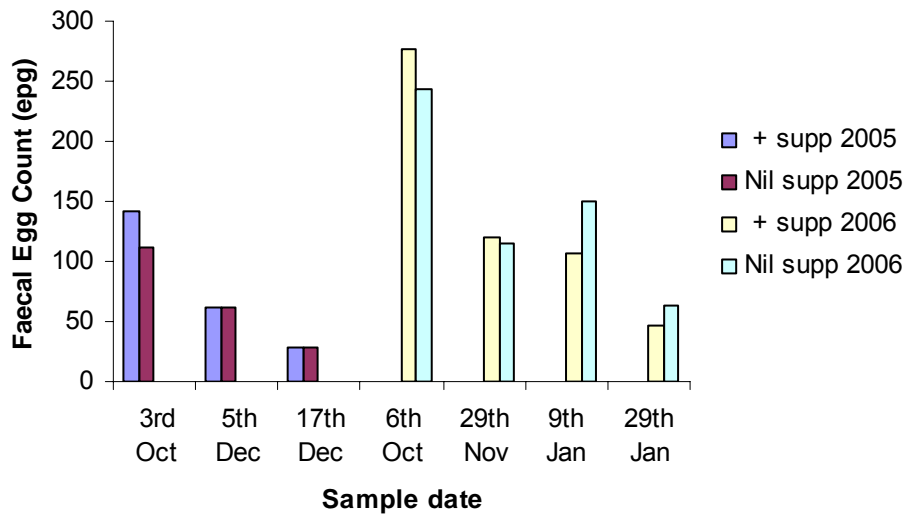


Figure 2. FEC (epg) in Experiment 2 in 2005 and 2006; Isd 2006, Jan 9=38 on perennial pasture.

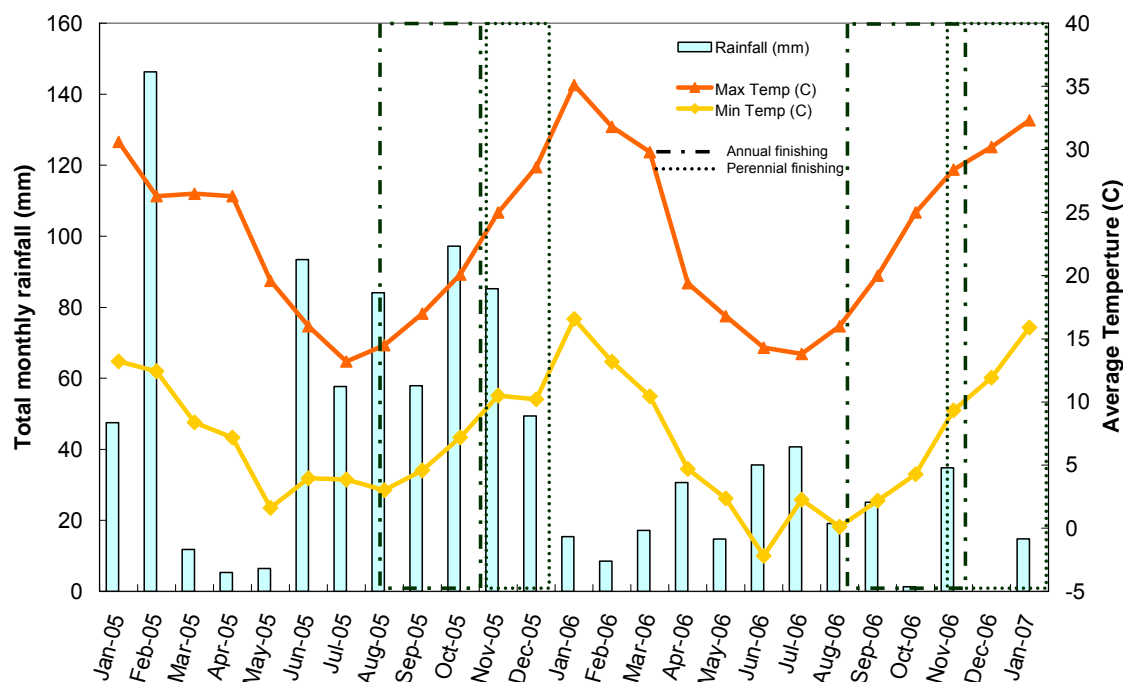


Figure 3. Total monthly rainfall (mm), maximum and minimum temperature (°C), and finishing periods during experiments.

Effect of soyabean meal supplementation on lamb growth rate and final liveweight

In Experiment 1, soyabean meal supplementation improved ($P < 0.05$) lamb growth rate from weaning to final liveweight in both finishing seasons (Table 2). Final liveweight was only increased ($P < 0.05$) in Experiment 1 in the 2006 finishing season. In Experiment 2, there was no effect of soyabean meal supplementation on growth rate or final liveweight in either finishing season (Table 3).

Table 2: Growth rate (g/day) and live-weights (kg) during the finishing period for lambs grazing annual pasture (Experiment 1) in 2005 and 2006

Measurement	2005 finishing season		2006 finishing season	
	Growth rate weaning to final	Live weight final	Growth rate weaning to final	Live weight final
Supplement				
YES	232	50.77	211	53.04
NO	196	46.53	184	49.82
LSD ($P=0.05$)	32	4.65	21	2.70

Table 3: Growth rate (g/day) and live-weights (kg) during the finishing period for lambs grazing perennial pasture (Experiment 2) in 2005 and 2006

Measurement	2005 finishing season		2006 finishing season	
	Growth rate weaning to final	Live weight final	Growth rate weaning to final	Live weight final
Supplement				
YES	273	45.84	209	50.71
NO	240	43.20	198	50.07
LSD ($P=0.05$)	35	3.56	38	5.23

Effect of soyabean meal supplementation on hot standard carcase weight (HSCW)

Soyabean meal supplementation resulted in heavier HSCW ($P < 0.05$) only in Experiment 1 in the 2005 finishing season (Table 4). In Experiment 2 there was no effect of soyabean meal supplementation on HSCW in either finishing season (Table 4).

Table 4: Hot Standard Carcase Weight (HSCW) (kg) of lambs finished on annual and perennial pasture systems in 2005 and 2006

Measurement	Experiment 1. Annual pastures		Experiment 2. Perennial pastures	
	HSCW 2005	HSCW 2006	HSCW 2005	HSCW 2006
Supplement				
YES	22.97	22.50	20.63	21.40
NO	20.67	20.97	19.22	20.70
LSD ($P=0.05$)	2.01	1.77	2.30	2.46

Feed on offer and pasture nutritive characteristics

Feed on offer in both experiments ranged between two and eight t DM/ha over the two finishing seasons (Figure 4). Pasture production was high in spring 2005 as a result of unusually high rainfall from September to December (Figure 3). Feedtest analysis of the soyabean supplement is shown in Table 5a. The CP of the pasture in Experiment 1 averaged 13.9% in 2005 and 12.5% in 2006 (Table 5b), and in Experiment 2, averaged 18.2% and 15.4% respectively for the two finishing seasons (Table 5c), demonstrating that the pastures where lambs were not supplemented had sufficient CP available for liveweight gain. ME in Experiment 1 was 10.1 and 8.5 MJ/kg DM for the 2005 and 2006 finishing seasons respectively, and in Experiment 2, was 9.2 and 8.4 MJ/kg DM (Tables 5b and 5c).

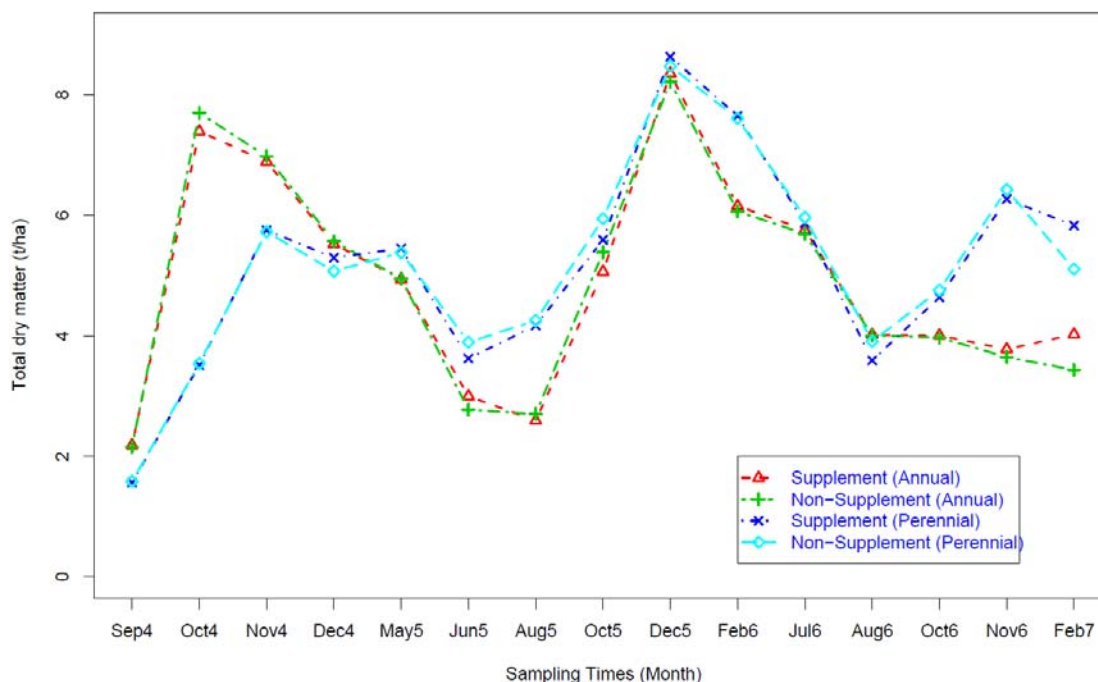


Figure 4. Total pasture mass (t DM/ha) on supplemented and non-supplemented plots during Experiments 1 and 2 from September 2004 until February 2007.

Table 5a. Feedtest™ analyses of organic soyabean meal and oaten hay

Test	Soyabean meal 2005	Soyabean meal 2006	Oaten hay
Crude protein (% DM)	42.1 (38)*	46.2	9
Neutral detergent fibre (% DM)	-	-	55.1
DM digestibility (% DM)	90.7	90.1	65
Metabolisable energy (MJ/kg DM)	18.2	15.8	9.6
Fat (Ether extract)	18.5	9.9	-

* 38% crude protein recorded on bag and used for supplement calculation

Table 5b. Feedtest™ analyses for annual pasture (Experiment 1) during finishing periods in 2005 and 2006.

Test	27/6/05	29/8/05	11/10/05	12/12/05	10/7/06	15/8/06	6/10/06	28/11/06
Crude protein (%DM)	19.2	16.9	12	7.4	15.4	16.3	9.4	8.8
Neutral detergent fibre (%DM)	50.6	44	44.9	61.8	63.8	55.7	54.9	74.8
DM digestibility (%DM)	69	76.1	74	54.2	58.3	63.9	67.3	46
Metabolisable energy (MJ/kg DM)	10	11.5	11.1	7.7	8.4	9.4	10	6.3

Table 5c. Feedtest™ analyses of perennial pasture (Experiment 2) during finishing periods in 2005 and 2006.

Test	12/7/05	29/8/05	11/10/05	12/12/05	10/7/06	15/8/06	6/10/06	28/11/06	8/1/07
Crude protein (%DM)	16.7	23.5	16.5	15.9	15.9	19.5	16.5	12.5	12.6
Neutral detergent fibre (%DM)	61.3	38.6	45.2	49	62.5	47.8	48	70.4	70.9
DM digestibility (%DM)	48.5	72.6	68.6	60.7	49.1	68.6	69.5	48.1	55.7
Metabolisable energy (MJ/kg DM)	6.7	10.9	10.2	8.8	6.8	10.2	10.3	6.7	8.0

Discussion

Faecal egg count was not reduced by soyabean meal supplementation; there are several reasons that could explain this result. Firstly, it is important to acknowledge the limitations in the FEC data as a result of experimental design, the small number of animals and the low levels of FEC measured. The FEC method has large variation and error (Miller *et al.* 2006), so the comparison that can be made between supplemented and non-supplemented lambs is limited. However, this method was employed to make the best use of available resources for organic producers.

Secondly, the CP content of the pasture in both experiments and years was in excess of what is required to meet the nutritional requirements of growing lambs (114 g [11.4 %] CP/kg DM for a 30 kg lamb growing at 200 g/day; Freer 2007), except for the last month of Experiment 1 in both years. In Experiment 1 in 2005, CP ranged from 19.2 % to 12 % during the finishing period, and in 2006 it ranged from 15.4 % to 8.8 %. In Experiment 2 in 2005, CP ranged from 23.5 % to 15.9 %, and in 2006 it ranged from 19.5 % to 12.5 %. These protein levels may have masked any effect that additional protein might have had on FEC. The success of reduced FEC from supplemented protein has generally been in circumstances where there has been nutritional stress and high worm burdens (Wallace *et al.* 1996, Datta *et al.* 1998, Louvandini *et al.* 2006). In the north east Victorian environment, where annual pasture based on subterranean clover has dominated in the past, protein would not normally have been limiting in the spring season; however, climate variability in the last 10 years has resulted in numerous failed spring seasons during which subterranean clover has died and protein from these pasture systems may have been limiting. In this context we considered that supplementary protein was worthy of investigation.

A 30 kg lamb consuming 1.4 kg DM/day and growing at 325g/day requires a daily ME requirement of 12 (MJ/kg DM). Experiment 1 had ME levels ranging from 11.5 to 7.7 MJ/kg DM in 2005, and in 2006, ME ranged from 10 to 6.3 MJ/kg DM. In Experiment 2, ME ranged from 10.9 to 8.8 MJ/kg DM in 2005, and in 2006, ranged from 10.3 to 6.7 MJ/kg DM. These energy levels are lower than what is required, but lambs in both experiments increased in liveweight during the finishing period. Lambs not receiving supplement grew at an average rate over the two years of 190 g/day in Experiment 1 and 219 g/day in Experiment 2. High fibre content in the pasture may have restricted intake, but this was not reflected in liveweight gain. Those lambs receiving supplementation acquired additional energy from the soyabean meal (all consumed), which had ME in 2005 and 2006 of 18.2 and 15.8 MJ/kg DM respectively. This may have contributed to significantly higher growth rates in this treatment.

Thirdly, rotational grazing and the use of clean pastures can reduce the level of intestinal parasite infection (Besier and Love 2003). In the first finishing season (2005) for both experiments, sub-plots were considered to be of low risk for worm infection, having had no grazing since early 2004. The experiment was conducted using rotational grazing practice, whereby lambs were rotated through three sub-plots every two to three weeks. This allowed for a period of at least four weeks before lambs were returned to a grazed pasture. In terms of the life cycles of the major worm species, this amount of time is insufficient to prevent re-infection. Southcott *et al.* (1976) have demonstrated that the main worm species can persist over 12 months in a temperate environment. Whilst strict grazing management practice to avoid parasitic larvae consumption has been recognised as an important non-chemical method for managing internal parasites (Larsen 1991, Eysker *et al.* 2005), it is not practical or viable for most producers to have multiple paddocks such that grazing occurs at extended intervals of months. The grazing period was, however, sufficient for new pasture growth to occur such that lambs were easily able to browse the herbage (Hodgson 1979) without having to graze close to ground level where the potential for ingestion of larvae is higher.

Supplementary soyabean meal resulted in increased growth rates in three out of four finishing seasons. According to SCA (1990) guidelines, lambs (30 kg liveweight) require 1.4 kg DM/day, and this can return a growth rate of 325 g/day, providing that the dry matter meets CP and ME requirements. Lambs receiving supplement on the annual pasture grew an average of 221 g/day, whilst those without supplement grew an average 191 g/day. Lambs receiving supplement on the perennial pasture grew an average 241 g/day, whilst those without supplement grew an average 220 g/day. Although there was variation in ME during the finishing periods, it is likely that lambs receiving supplement were more able to meet the required intake of CP and ME to grow faster than lambs without supplement.

Lambs were finished on the two pasture systems in quite contrasting seasons, and this may have had an effect on the results. Rainfall during the finishing period (July – October) of the annual pasture system in 2005 was 297mm, and in 2006 it was 88 mm. In the perennial pasture system in 2005, rainfall during the finishing period (October – December) was 232 mm compared with 51 mm in the equivalent period in 2006. The very wet season in 2005 would usually have meant a greater potential for parasite burdens for lambs, but levels were kept low due to the 'low risk' (no grazing for 12 months) nature of the pasture systems. In 2006, which was exceptionally dry, FEC was elevated during the annual system finishing season, irrespective of the dry weather. This raises the issue of whether the grazing system would have been sustainable in terms of FEC given a wetter spring season. Seasonal variation cannot be avoided when conducting a field experiment. The experimental design was conservative, being based on average pasture growth where CP was not expected to be high. With regard to the higher rainfall in 2005, and increased pasture growth, stocking rate could not have been increased to account for this growth because of animal ethics requirements and project budget constraints. Future experiments should incorporate flexibility in design to allow for variable stocking rates.

Soyabean meal supplementation resulted in increased liveweight in lambs in the north east Victorian environment, but did not result in reduced FEC. Although a direct comparison between the annual and perennial finishing systems cannot be made, higher final liveweight was recorded in lambs finished on annual pasture, but faster growth rates were recorded in lambs finished on perennial pasture. The financial viability of supplementary feeding with a high value protein source such as soyabean meal would have to be evaluated against the likely return from extra growth achieved and higher carcass weight of certified organic lamb product. There are risks for organic producers in finishing lambs during the spring on annual pasture systems, especially if pastures are not initially 'clean', and if there is average spring rainfall to allow for parasite life cycle development. Longer periods of time for pasture to become clean after grazing are generally not practical in many farming businesses, so organic producers could reduce this risk by finishing lambs on perennial pastures during the summer months when the risk of internal parasite infection is lower.

Acknowledgments

The authors wish to acknowledge the funding provided for this research by the Victorian Department of Primary Industries through the Naturally Victorian Initiative. We are grateful for expert advice from parasitologists, Noel Campbell and Tricia Veale and technical support from John Schneider, Wayne Dempsey, Tim Enshaw and Gareth Phillips. Manuscript review by DPI staff is gratefully acknowledged.

References

- AFIA 2002. Australian Fodder Industry Association, www.afia.org.au/information/technical_notes/, accessed 22 September 2009.
- Barger, I 1997. Control by management. *Veterinary Parasitology*, 72: 493-506.
- Besier, RB and Love, SCJ 2003. Anthelmintic resistance in sheep nematodes in Australia: the need for new approaches. *Australian Journal of Experimental Agriculture*, 43: 1383-1391.
- BFA 2006. Australian Organic Standard 2006, Biological Farmers of Australia, www.bfa.com.au, accessed 17 September 2008.
- Bransby, DI, Tainton, NM 1977. The disc pasture meter: possible applications in grazing management. In *Proceedings of the Grassland Society of Southern Africa*, 12: 115-118.
- Cabaret J Bouilhol M and Mage C 2002. Managing helminths of ruminants in organic farming. *Veterinary Research*, 33: 625-640.
- Coop, RL and Holmes, PH 1996. Nutrition and parasite interaction. *International Journal for Parasitology*, 26: 951-962.
- Coop, RL and Kyriazakis, I 1999. Nutrition-parasite interaction. *Veterinary Parasitology*, 84: 187-204.
- Datta FU, Nolan JV, Rowan JB, Gray D 1998. Protein supplementation improves the performance of parasitised sheep fed a straw-based diet. *International Journal for Parasitology*, 28: 1296-1278.
- Eady, SJ, Woolaston, RR, Mortimer, SI, Leiner, RP, Raadsma, HW, Swan, AA, Ponzoni, RW 1996. Resistance to nematode parasites in Merino sheep: sources of genetic variation. *Australian Journal of Agricultural Research*, 47: 895-915.
- Eysker M, Bakker N, Kooymen FNJ, Ploeger HW 2005. The possibilities and limitations of evasive grazing as a control measure for parasitic gastroenteritis in small ruminants in temperate climates. *Veterinary Parasitology*, 129: 95-104.
- Freer, M 2007. *Nutrient Requirements of Domesticated Ruminants*, CSIRO Publishing, Melbourne, VIC.
- Hannigan, G 2007. *The Power of Organics – The Export Opportunities for Organic Lamb; A Report for Nuffield Australia Farming Scholars*, Nuffield Australia, Griffith, NSW.
- Hodgson J 1979. Nomenclature and definitions in grazing studies. *Grass and Forage Science* 34: 11-18.
- Isbell, RF 1996. *The Australian Soil Classification*. CSIRO Publishing, Collingwood, VIC.
- Kahn, LP 2003. Regulation of the resistance and resilience of periparturient ewes to infection with gastrointestinal nematode parasites by dietary supplementation. *Australian Journal of Experimental Agriculture*, 43: 1477-1485.
- Keatinge, R, Jackson, RF, Kyriazakis, I, Deane, J 2004. Controlling internal parasites in organic sheep and cattle. In *Organic Farming: science and practice for profitable livestock and cropping*. Proceedings of the British Grassland Society/AAB/COR Conference, Newport, Shropshire, UK, 20-22 April 2004, pp. 73-82.
- Larsen J 1991. 'Wormplan - Managing drench resistance in your flock.' (Agmedia: Melbourne, VIC)
- Liu SM, Masters DG, Adams NR 2003. Potential impact of nematode parasitism on nutrient partitioning for wool production, growth and reproduction in sheep. *Australian Journal of Experimental Agriculture*, 43: 1409-1417.
- Louvandini H, Veloso CFM, Paludo GR, Dell'Porto A, Gennari SM, McManus CM 2006. Influence of protein supplementation on the resistance and resilience on young hair sheep naturally infected with gastrointestinal nematodes during rainy and dry seasons. *Veterinary Parasitology*, 137: 103-111.
- Miller, CM, Waghorn, TS, Leathwick, DM, Gilmour, ML 2006. How repeatable is a faecal egg count reduction test? *New Zealand Veterinary Journal*, 54: 323-328.
- Morley, FHW and Donald, AD 1980. Farm management and systems of helminth control. *Veterinary Parasitology*, 6: 105-134.
- NASAA 2004. amended 13th May 2008, NASAA Organic Standard, National Association for Sustainable Agriculture Australia Limited, accessed 17th September 2008.
- Niezen JH, Robertson HA, Waghorn GC, Charleston WAG 1998. Production, faecal egg counts and worm burden of ewe lambs which grazed six contrasting forages. *Veterinary Parasitology*, 80: 15-27.
- Payne, RW, Harding, SA, Murray, DA, Soutar, DM, Baird, DB, Glaser, AI, Channing, IC, Welham, SJ, Gilmour, AR, Thompson, R, Webster, R 2008a. GenStat Release 11 Reference Manual, Part 3 Procedure Library PL19. VSN International, Hemel Hempstead, UK.
- Payne, RW, Murray, DA, Harding, SA, Baird, DB & Soutar, DM 2008b. GenStat for Windows (11th Edition) Introduction. VSN International, Hemel Hempstead, UK.
- Ramirez-Restrepo CA, Barry TN, Pomroy WE, Lopez-Villalobos N, McNabb WC, Kemp DR 2005. Use of *Lotus corniculatus* containing condensed tannins to increase summer lamb growth under commercial

- dryland farming conditions with minimal anthelmintic drench input. *Animal Food Science and Technology*, 122: 197-217.
- Sackett, D, Holmes, P, Abbott, K, Jephcott, S, Barber, M 2006. Assessing the economic cost of endemic disease on the profitability of Australian beef cattle and sheep producers (Sydney, Meat and Livestock Australia), 119 pp.
- Saul, GR and Kearney, GA 2002. Potential carrying capacity of grazed pastures in Southern Australia. *Wool Technology and Sheep Breeding*, 50:3, 492-498.
- SCA 1990. Standing Committee on Agriculture 'Feeding standards for Australian livestock - Ruminants.' (CSIRO: Australia)
- Scales GH, Knight TL, Saville DJ 1994. Effects of herbage and feeding level on internal parasites and production performance of grazing lambs. *New Zealand Journal of Agricultural Research*, 38: 237-247.
- Southcott, WH, Major, GW, Barger, I A 1976. Seasonal pasture contamination and availability of nematodes for grazing sheep. *Australian Journal of Agricultural Research*, 27: 277-286.
- Steel, JW 2003. Effects of protein supplementation of young sheep on resistance development and resilience to parasitic nematodes. *Australian Journal of Experimental Agriculture*, 43: 1469-1476.
- 'T Mannetje, L and Haydock, KP 1963 The Dry-Weight-Rank Method for the Botanical Analysis of Pasture, *Journal of the British Grassland Society*, 18: 268-275.
- Vaarst, M, Roderick, S, Lund, V and Lockeretz, W (Eds.) 2004. *Animal Health and Welfare in Organic Agriculture*, CABI Publishing, Wallingford, UK.
- Wallace, DS, Bairden, K, Duncan, JL, Fishwick, G 1995. Influence of supplementation with dietary soyabean meal on resistance to haemonchosis in Hampshire down lambs. *Research in Veterinary Science*, 58: 232-237.
- Wallace, DS, Bairden, K, Duncan, JL, Fishwick, G 1996. Influence of soyabean meal supplementation on the resistance of Scottish blackface lambs to haemonchosis. *Research in Veterinary Science*, 60: 138-143.
- Whitlock HV 1948. Some modifications of the McMaster helminth egg counting technique and apparatus. *Journal of the Council of Scientific and Industrial Research Australia*, 21: 177-180.
- Wynen, E 1992. Conversion to organic agriculture in Australia: Problems and possibilities in the cereal-livestock industry. National Association for Sustainable Agriculture Australia, ISBN 1 875218 08 4.